



FOREST PEST MANAGEMENT

Pacific Southwest Region

Report No. 85-13

3430 Evaluation
March 21, 1985

A BIOLOGICAL EVALUATION OF PORT-ORFORD-CEDAR ROOT ROT ON THE GASQUET RANGER DISTRICT, SIX RIVERS NATIONAL FOREST

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ABSTRACT

The Gasquet Ranger District is developing a management strategy for Port-Orford-cedar root rot. This evaluation presents the District's situation paper in the format of a biological evaluation. Alternatives for managing the disease in three situations -- uninfested stands, but with a high risk of disease introduction; incipient infestation identified, with high potential for loss of downstream cedar; and, areas with dead or dying cedars over a period of years -- are discussed. The biology of the disease and its distribution in California are presented.

INTRODUCTION

Port-Orford-cedar root rot, caused by the fungus Phytophthora lateralis, has been present on the Gasquet Ranger District, Six Rivers National Forest, for a number of years. The disease is now well-established there, and is spreading to uninfested stands. The District is concerned with the real potential for the loss of a valuable resource, and is facing the decision to implement procedures for reducing the impact of the disease.

The District has organized an interdisciplinary team to develop a practical, effective, and environmentally sound control strategy for Port-Orford-cedar root rot. A preliminary team meeting was held on January 16, 1984 and a draft "situation paper" produced. The team divided existing disease incidence and potential loss of Port-Orford-cedar into three situations (uninfested, but with high risk of disease introduction; incipient infestation identified, with high potential for loss of downstream cedar; areas with dead or dying cedar over a period of years), and listed the objective and some of the possible control measures for each of the three. On February 1 and 2, 1984, Dave Schultz and I from Forest Pest Management and David Adams, California Department of Forestry, met with some of the team members and discussed the feasibility of various management alternatives while visiting examples of the three situations in the field.

At a joint Region 5/Region 6 Port-Orford-cedar root rot management workshop in Grants Pass on April 24 and 25, 1984, it was agreed that the Region 5 Forest Pest Management Staff would write the Gasquet District "situation paper" in the format of a biological evaluation. The format would provide the opportunity to list advantages and disadvantages by alternative, and may be in a format useful to other Districts and Forests.

The following is the biology of the disease, its distribution in California, and alternatives for managing the disease, based on the District's draft.

BIOLOGY OF PHYTOPHTHORA LATERALIS

Phytophthora lateralis is a soil-invading, root-inhabiting fungus that infects succulent Port-Orford-cedar roots, kills the roots and girdles the tree at the root collar. In the forest, the fungus attacks only Port-Orford-cedar. Young feeder roots are infected first. The fungus then spreads into the inner bark of the main trunk to kill the tree. A sharp line of demarcation between the white color of the live cambium and phloem and the cinnamon to dark brown color of the dead tissue is evident at the root collar. As the fungus begins girdling the trunk at the soil line, the foliage throughout the crown turns yellow, then bronze, then light brown. Attack of weakened, dying trees by cedar bark beetles (Phloeosinus spp.) may occur.

The fungus forms sac-like reproductive structures (sporangia) which release motile zoospores under favorable soil temperatures (10-20 C) and high soil moisture conditions. Zoospores can be spread locally in free soil water and over longer distances in surface water. Permeation of surface water containing zoospores into the soil can result in infection of root tips. When zoospores reach susceptible root tips, they germinate, penetrate host roots, and initiate infection. Occasional infection of foliage can occur when low-hanging branches brush against infested soil during wet, windy weather.

The fungus also forms two types of thick-walled resting spores (asexually formed chlamydospores and sexually formed oospores) in soil organic matter and in host roots. These spores germinate in saturated, cool soil and then form sporangia which release zoospores to initiate new infection. If soils infested with the thick-walled spores are carried to uninfested areas, either by water or other agents, new infections can occur. These resting spores are resistant structures which can survive in the soil during dry, warm weather when conditions are unfavorable for growth of the fungus. Ideal conditions for growth of the fungus and spread of the disease are thus during the cool, wet, late fall, winter, and early spring months.

Because the fungus is soil-borne, produces motile spores, and rarely forms spores above ground, the distribution of the disease is associated with water drainages, surface water movement, and with movement of infested soil. In Oregon, spread of the disease over long distances took place through movement of infected planting stock, and through movement of infested soil during construction, forest road maintenance and use, and logging operations. Initiation of many new disease centers thus occurred along roads where logging and road building activities took place. Infested soil can also be carried by cattle or wild game. Once the fungus is moved to a new area, local spread by water drainages becomes important in buildup of the disease and spread downslope.

EXTENT OF THE DISEASE IN CALIFORNIA

Stands of Port-Orford-cedar on Federal, State and private lands in northern California were surveyed in the spring of 1980 for the presence of Phytophthora root rot (reference Forest Pest Management Report No. 80-1, 1980). Except for its occurrence on ornamental cedar at one site in the city of Eureka, the disease was confined to the Smith River drainage in Del Norte County. Numerous dead and dying Port-Orford-cedar were found along the Middle Fork of the Smith River, from Cedar Rustic Campground west to Jedediah Smith Redwoods State Park. Four sites along the South Fork were infested, as well as one site along Knopki Creek road and portions of the upper Myrtle Creek drainage. The disease was not found on private timber lands (Arcata Redwoods, Rellim Miller), on the Orleans Ranger District in Humboldt County, the Happy Camp District in Siskiyou County, or on the private and Shasta-Trinity National Forests lands in Trinity and Shasta Counties.

Most of the same Port-Orford-cedar stands surveyed in 1980 were re-surveyed in the fall and winter of 1983-1984. Areas in the vicinity of the Mt. Shasta Ranger District, the Happy Camp Ranger District, the Orleans Ranger District, and private timber lands west and south of the Gasquet District are apparently not infested. The disease appears to be still confined to the Smith River drainage and nearby areas of the Siskiyou National Forest. Region 6 has reported the disease in California near the State Quarantine Station at Elk Valley and at locations on the Siskiyou National Forest in Del Norte County.

The number and extent of infested areas on the Gasquet District has increased since 1980 (Figure 1). Salvage of Port-Orford-cedar has occurred and is planned for the Cedar Rustic Campground area, the Baker Flat area along Shelly Creek, and areas along the South Fork Road. Infestations at Coon Creek, Deer Creek and Big Flat Campground are directly associated with recent logging activity or with use by the general public for a water supply or bough cutting. The extent of the infestations along Shelly Creek and in the French Flat area suggest that the disease was present, but not observed, in the 1980 survey.

MANAGEMENT CONSIDERATIONS

A decision to manage Port-Orford-cedar to minimize root rot damage involves a long-term commitment on the part of the District, the Forest, and the general public. Because of the relatively long rotation age needed for production of high quality, commercial Port-Orford-cedar (up to 200 years), and the high susceptibility of the species to the disease once the fungus is introduced into an area, an aggressive management program is the prudent course of action if desired stands of Port-Orford-cedar are to be protected.

Once cedar root rot has become established in an area, the only means of eliminating the disease is to eliminate the host from the site for a period of years. A minimum of three to five years has been suggested as the interval needed before the fungus dies out in the absence of the host (Roth, personal communication). Chemical control methods applicable to field situations, or a usable level of host resistance to the fungus, are not currently available and probably will not be available for many years. Currently-infested areas are a

source of inoculum. Desired stands can be kept free of the disease by minimizing or preventing the spread of inoculum (infested soil, infected host tissues) from infested to uninfested areas.

The first essential step in management should be to know where the disease currently is. If the risk of spread by vectors is to be minimized, infested areas must be known, mapped, preferably marked or signed on the ground, and the information made available to users of the forest. The significance of the information, i.e., what the consequences of spreading the disease are, must also be effectively conveyed.

A second essential step in a long-term management commitment would be to decide where Port-Orford-cedar can be successfully managed. Sites both suitable for growth of the species and unlikely to become infested with the disease need to be located. Only then should specific steps be taken to minimize vector activity and impact for protection of these specified sites.

Because of the nature of disease spread, Port-Orford-cedar in vulnerable locations will eventually become infected, whether aggressive management is implemented or not. Vulnerable sites include those 1) downslope or downstream from infested sites, 2) adjacent to and downslope from infested, poorly-maintained roads, and 3) sites in draws and near or in wet areas. Production of Port-Orford-cedar should be concentrated on appropriate sites unlikely to be reached by the fungus. Roth (unpublished) has termed these areas "protectable sites", or "Port-Orford-cedar production sites". These protectable sites are characterized by 1) being upslope from infested areas or upslope from areas likely to become infested, 2) having limited access through and upslope from them, and 3) receiving no drainage water from infested areas.

A third factor to consider in a long-term commitment is the public's reaction if control measures that involve limiting access or steam-cleaning are implemented. Cooperation can be gained only through a well-thought out and aggressive educational program. In Australia, for example, a well-advertized publicity campaign was begun one year before limiting access by gating of roads to Jarrah dieback stands. The public respected the quarantine measures because they understood, and agreed with, the reasons for them.

These three steps or factors -- knowing where the disease is, deciding where Port-Orford-cedar can be successfully managed, and enlisting public cooperation -- are a necessary part of the commitment. After these long-term considerations are implemented, steps can then be successfully taken on specific sites to minimize the impact of the disease.

MANAGEMENT ALTERNATIVES

Various alternatives are available for protecting the Port-Orford-cedar resource. These alternatives, and their effectiveness, vary for any site depending on the current level of *Phytophthora* root rot present. Below are three situations. A description of each situation, the objective, and available management alternatives follow.

Situation 1 -- Urgent Areas: Uninfested, but with high risk of disease introduction.

Objective: Prevent, or reduce the risk of, the introduction of Port-Orford-cedar root rot into the area or watershed.

Areas on the Gasquet Ranger District that fit this situation include uninfested areas containing significant volumes of Port-Orford-cedar that are or will be accessible by road or that receive drainage water from infested areas. Some examples are the headwaters of uninfested drainages such as Jones Creek, Hurdygurdy Creek, and Knopki Creek. Other areas include portions of the Orleans Ranger District along major roads, and portions of the Happy Camp District that are accessible to traffic from infested areas on the Siskiyou National Forest over the Grayback Road. Areas on the Mt. Shasta Ranger District are at less of a risk because of their distance from known infested areas, but may be included here because of the potential loss in scientific and aesthetic value that the cedar, at the limits of its range, represents.

Alternatives:

1. Do Nothing. The risk of introducing the disease into uninfested stands of Port-Orford-cedar will increase as the disease intensifies in currently-infested areas and as inadvertent movement of contaminated soil increases. The protectability of the site will also influence the chance for infestation occurring. Isolated areas upslope from infested sites with limited access will be easier to protect than areas adjacent to infested sites. The successful establishment of the disease after introduction will depend on how conducive the area is to survival of *P. lateralis*. Moist sites will be more favorable than dry sites on serpentine soils. Once the disease is established, the loss of the site for future commercial production of Port-Orford-cedar, or a decrease in aesthetic value, is assured.

2. Remove Vulnerable Port-Orford-Cedar. Removing cedars from moist habitats, from near culverts, or downslope from roads, and suppressing cedar reproduction, would eliminate the host needed for pathogen survival. Removing or killing these healthy Port-Orford-cedar before infection occurs in areas with a high potential for infestation would reduce the risk of disease establishment. This removal should be done with steam-cleaned equipment to avoid introduction of the pathogen and disease establishment in the remaining cedar. For example, the Powers Ranger District, Siskiyou National Forest, is attempting to remove all cedar from a 15 meter band along streams and below roads.

3. Regulate Entry of Vectors. Restricting entry of contaminated equipment into noninfested areas designated for protection would reduce the risk of disease introduction. Entry could be restricted by permanent gating of roads, or by gating during the wetter months of the year. Maintaining existing roads to reduce downslope spread of infested soil and water, and controlling erosion and drainage within the area, would reduce the risk of the disease becoming established if introduced. Contract restrictions may prove useful in protecting specific stands. Clauses such as requiring entry with steam-cleaned equipment only, restricting logging operations to periods of dry weather, not allowing

tractor logging, and requiring the gating of roads to limit travel during the wet season have been included in contracts. These regulatory procedures would need to be implemented and supported over long periods of time in order to be successful.

Situation 2 -- Areas With Incipient Infestation: Incipient infestation identified, with high potential for loss of downstream Port-Orford-cedar.

Objective: Reduce risk of spread of the disease to downstream Port-Orford-cedar.

Areas with incipient infestation are areas where only few cedar, in one location, are recently dead or with fading crowns, indicating a recent introduction of the pathogen with little or no spread downslope.

One example on the District is at a tributary of Coon Creek (T. 16N., R. 2E., Sec. 14), easily accessible to recreationists and to tanker trucks that use the river as a source of water for watering District roads. Three recently-dead sawtimber-sized Port-Orford-cedar and a few fading Port-Orford-cedar seedlings were present. Although the disease was not confirmed at the headwaters of Jones Creek, the District needs to know what alternatives are available if incipient infestation is noted in areas such as this that are easily accessible.

Alternatives:

1. Do Nothing. Once the disease is introduced and becomes established, mortality will continue to occur. The fungus will spread via root contact and zoospores to adjacent cedars and locally downslope in drainage water. Infestation at the headwaters of a drainage will result in downstream spread of the fungus and eventual infestation of the entire drainage. These sites will be additional sources of contamination.

2. Remove Port-Orford-Cedar. The killing or removal of all cedar, including reproduction vulnerable to infection, will reduce risk of downslope spread from incipient infestation. The distance from which uninfected cedar should be removed will vary with how long the infestation has been present and with local topography. The Powers Ranger District has attempted to contain incipient infestation by creating a 200-foot cedar-free buffer strip around an infection center. The buffer strip would need to be maintained free of cedar reproduction for a period of 3 to 5 years (the period estimated to be needed for the fungus to die-out in the soil).

3. Regulate Vectors. The same considerations listed under Regulating Entry of Vectors under Situation 1 above would need to be considered. In addition, all equipment used in the area should be steam-cleaned before leaving the site to limit spread to other areas. If the potential for economic or aesthetic loss is great, prohibiting any entry, after removing the infected trees and creating a buffer, should be considered. This would limit local as well as long-distance spread.

Situation 3 -- Heavily Infested Areas: Areas with dead or dying Port-Orford-cedar over a period of years.

Objective: Prevent or reduce risk of export of the fungus.

Areas that fit this situation on the Gasquet District include, among others, Highway 199 (Middle Fork of Smith River) from Cedar Rustic Campground to Jedediah Smith Redwoods State Park, the South Fork Road (South Fork of the Smith River) from Big Flat Station to Highway 199, and Road 316 (Shelly Creek) in the Baker Flat area.

Alternatives:

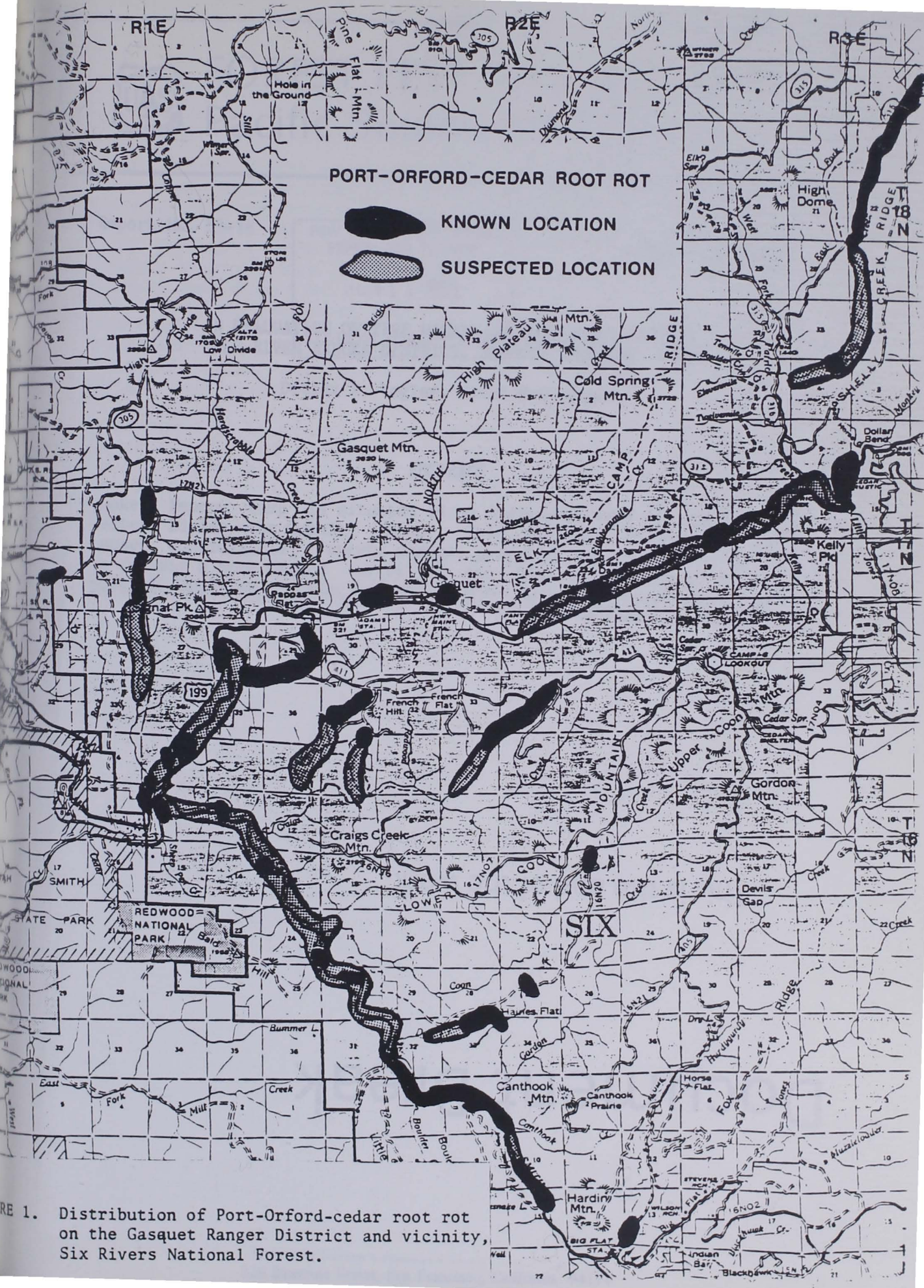
1. Do Nothing. Mortality in infested areas will continue as the disease intensifies. Continued cedar reproduction in the areas will perpetuate the disease. The reproduction will likely become infected and die before reaching merchantable size. These contaminated sites will remain as a continued source of inoculum, and long-distance spread to vulnerable uninfested areas by agents such as contaminated logging equipment will occur. Continued entry for salvage will conflict with the goal of reducing disease spread and impact. Periodic salvage would move infested soil to other parts of the stand during each logging operation, and would increase the risk of long-distance spread.

2. Remove Port-Orford-Cedar. Complete elimination of cedar from these sites in an attempt to eradicate the disease would be difficult because the species is a prolific seed producer. It may be well to assume that most, if not all, of these areas are "vulnerable" sites, and will not produce commercial cedar in the future.

Eliminating the host from these areas would also preclude the chance for naturally-occurring resistant genotypes to express themselves. The collection of Port-Orford-cedar seed from these sites should be considered for possible future studies on resistance.

3. Regulate Vectors. Complete closure of infested areas would limit the chance of long-distance spread of the disease, but would be costly as well as impractical. Less restrictive regulations would reduce the risk of spread. Salvaging would be permitted if precautions -- such as entering the stand as few times as possible, use of cable or helicopter yarding, operating only during dry soil conditions, maintaining roads, and cleaning all equipment before leaving -- are implemented.

An aggressive information system, including posting signs at infested areas, brochures, and news articles to inform the public, would be useful, but would have to be maintained for long periods of time.



RE 1. Distribution of Port-Orford-cedar root rot on the Gasquet Ranger District and vicinity, Six Rivers National Forest.